The Role of Variability in Mine Burial Prediction

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LONG-TERM GOALS

The ultimate long-term goal of the ONR Mine Burial Prediction (MBP) program is the development of mine burial probability models that incorporate dynamic coupled processes, seafloor material properties, and different mine types. A second major thrust is on short-term applied research that will provide Fleet Aids for the operational Navy. The short-term effort will provide the operational Navy with improved mine burial predictive capabilities by using existing models and an enhanced understanding of environmental databases and seafloor geotechnical properties. An important part of that effort will involve designing user interfaces that will both display the complexities and uncertainties of the problem while remaining user-friendly for the sailor. As better models are developed during the course of the program, they will be incorporated into the existing predictive systems.

OBJECTIVES

Objectives during the past year were to (1) organize meetings of MBP investigators, (2) participate in research cruises in 2003 and plan for fieldwork in 2003-2004, (3) develop a data reduction system for the 4 new Acoustic Registration Mines (ARMs) (4) work on the NATO Mine Burial Assessment Specialist Team (MBAST), and (5) analyze Martha's Vineyard Coastal Observatory (MVCO) cores and implement sediment acoustic modeling programs to use in field survey interpretation.

APPROACH

Meeting organization and cruise participation need no explanation. Cores were split during three days at the Woods Hole Core Library. The cores were cut into sections (when necessary) and digitally photographed before being described and sampled. Images were later combined into master images of each core and added to the MBP website. Samples were returned to Hawaii for grain size analysis using dry sieves.

ARM data (approximately 12 Gbytes from 4 mines) were translated into images representing individual sensors over the entire time of the experiment. Algorithms were developed to pick reflected arrivals from outside the mine body. Those arrivals are combined to form images of the seafloor around a mine over the course of the experiment.

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I will be participating in an Impact burial research cruise with scientists from NRL and FWG aboard the German research vessel PLANET in November, 2003. We will be collecting bottom samples, penetrometer data, and Acoustic Sediment Classification System data at sites where FWG has already deployed an impact registration mine.

WORK COMPLETED

I organized – with Al Hine and Peter Howd of USF – the third annual MBP investigators meeting at Clearwater Beach in January. We wrote and circulated a report of the meeting. With Peter Traykovski (WHOI), I organized a planning meeting in July of participants in the upcoming MVCO field experiment, due to begin on September 30. (2) I participated in 2 Indian Rocks Beach (IRB) research cruises. During the first we deployed registration mines and instrumented quad-pods. The second cruise was a re-survey of the IRB experiment area after a storm had passed through the area. (3) I have done a preliminary conversion of all of the data collected by the ARMs during the IRB experiment - approximately 65 days worth. Each sensor has been examined over the length of the experiment. I am presently finishing a series of routines to describe from the acoustic data the extent of burial of a mine during a single point in time and the topology of the scour pit around that mine. (4) I attended an MBAST meeting in London in June. I presented a summary of current Subsequent Burial models and showed some initial results from the IRB field experiment. (5) I worked on the MVCO cores with Ilya Buynevitch (USGS). We split, described, and sampled the cores at the core laboratory at WHOI. In Hawaii, my undergraduate assistant and I did grain size analyses on 118 samples from 36 cores. I implemented a version of the Biot/Stoll model for marine sediments and used it in modeling some older carbonate sediment data (see "Publications" below).

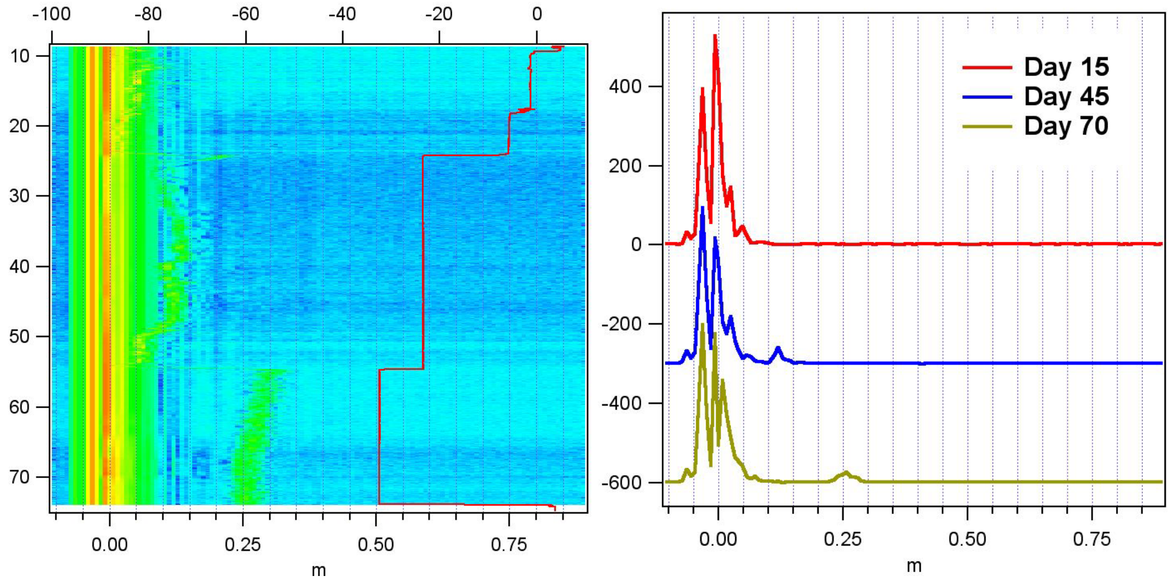

Figure 1. Left - An example of the complete record of a single ONR Mine 1 sensor over the time span of the IRB experiment. The left axis is Days (1/1/03=day 0). The figure is made up of a little over 2,600 lines; data collected at 30 minute intervals over a period of 65 days. Returns start at 0m. Signal from less than 0m is electronic noise associated with the outgoing pulse. The red line is the mine rotation (top scale in degrees) recorded by internal gyros. Right - Three individual signals from the same mine. Vertical scale is integrated acoustic power. Ring-down of the electronics (everything from the left side to a little past 0) makes picking arrivals from near the mine body difficult. Note in both figures that the position of the reflected arrival changes when the mine rotates. The arrival is from near the mine body on Day 15, about 12cm on Day 45, and near 25cm by Day 70.

RESULTS

An example of some individual signals returned from one of the ARMs, as well as a representation of that sensor over the entire IRB experiment is illustrated in Figure 1. There is excellent agreement between changes in the position of returns reflected from outside the mine body and times when the mine rotates. Pressure and inclination data (not shown) show that the rotation occurs when the mine rolls into scour pits that develop generally during brief (1-2 days) periods of storm and enhanced wave activity.

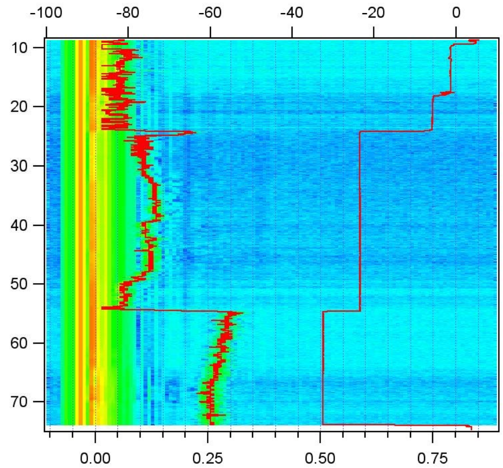

Figure 2. Same data as Figure 1. Results of the automatic peak picking routine are highlighted in red. Arrivals are from near the mine body up to Day 25 and move farther away over time in distinct intervals.

The first order of business in processing of the ARM data is picking of reflected arrivals. The amount of electronic noise close to signal origin makes this a bit difficult when the return comes from close to the mine body or is of unusually low amplitude, as might be the case when the surface reflecting the signal is not near-normal to the signal vector. An example of an automatic peak picking routine run on the data in Figure 1 is shown in Figure 2.

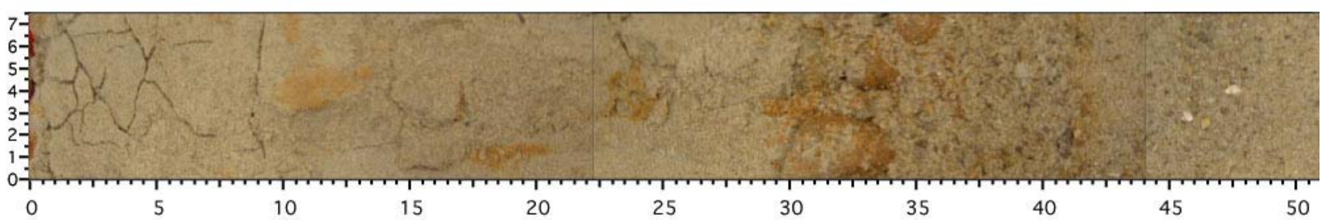

Figure 4. Composite digital image of the upper 50cm of Core 3.2. The image shows a fine grained layer of tan sand from 0-30cm. Between 30 and 35cm there is a gravel/cobble layer, underlain by coarse grained gray-spotted tan sand.

Data from the grain size analyses of the MVCO cores are presented in Figure 3. A preponderance of the samples are coarse grained and reasonably well sorted. There is a smaller grouping of fine sands that were collected from a distinct layer at the top of the sediment column in some places. Often the fine sand layer is separated from the coarse sands by a gravel or cobble zone approximately 5cm thick (Figure 4).

IMPACT/APPLICATIONS

The modeling and field studies will eventually result in an improved ability to predict the fate of mines on the seafloor. We will also develop much improved methods for presenting stochastic data to operators in the Fleet.

TRANSITIONS

None so far.

RELATED PROJECTS

In my capacity as Coordinator of the Mine Burial Prediction program I am working closely with all of the other MBP investigators. See www.mpb.unh.edu for a list.

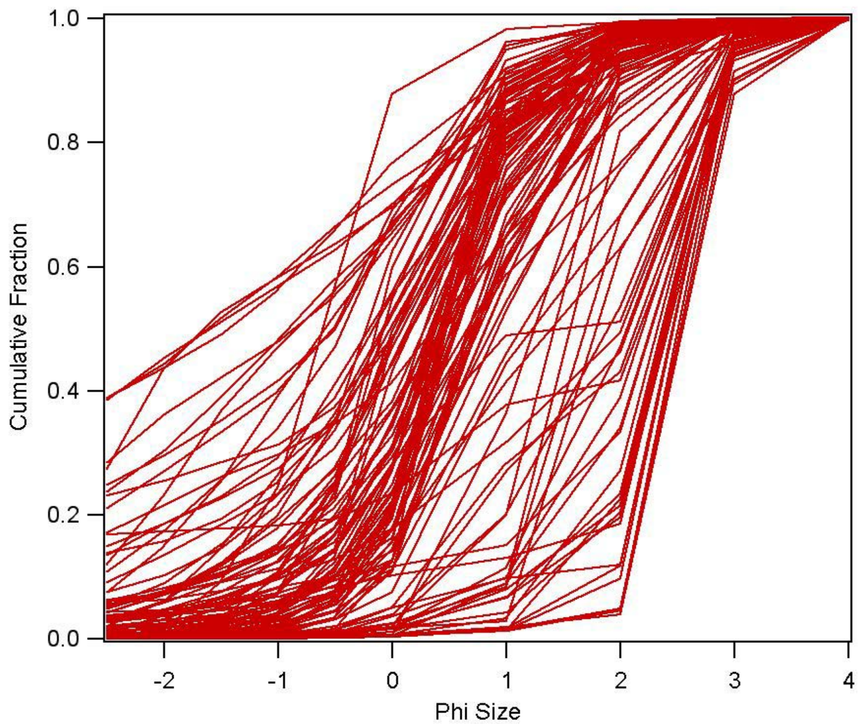

Figure 3. Results of grain size analyses of MVCO cores. Cumulative percent from 0 to 1 is plotted versus grain size in Phi units. Most of the data have a median size between Phi=0 and Phi=1; a coarse sand. There is another smaller clustering of samples between Phi=2 and Phi=3 representing fine sand layers.

PUBLICATIONS

Fu, S.S., C. Tao, M. Prasad, R.H. Wilkens, and L.N. Fraser. Acoustic properties of coral sands, Waikiki, Hawaii, submitted to JASA, [in revision].

Tao, C., S. Baffi, R.H. Wilkens, S.S. Fu, and M.D. Richardson. Compressional wave velocity dispersion and attenuation in carbonate sediments, Kaneohe Bay, Oahu, submitted to Geophys. Res. Lett.